REMARKS/ARGUMENTS

The subject invention relates to improvements in laser machining. As defined in the specification, laser machining includes, for example, grooving, drilling and etching procedures where material is removed from the workpiece. (Specification, page 8, paragraph 32) In accordance with the subject invention and as defined in the amended independent claims, machining is improved by creating a thin, flowing layer of fluid across the surface of the workpiece in the region being exposed to the laser radiation. The thin fluid layer is defined to be between 25 microns and 100 microns thick.

The thickness of the fluid layer is important to achieving optimum machining results. When the fluid layer is at the proper thickness, most of the laser light passes through the fluid and can be absorbed in material of the workpiece. The heating of the workpiece causes some of the fluid to vaporize near the surface of the workpiece. The overlying fluid prevents the vapor from escaping and instead, creates microbubbles in the fluid. The collapse of the bubbles creates acoustic shocks or sonic cavitation that adds a mechanical assistance to removal of material from the workpiece thereby increasing ablation rates.

If the layer of fluid is too thick, efficiency and ablation rates will be reduced. It is believed that the microbubble formation may create small lenses in the fluid that that disperse the laser light. If the layer of fluid is too thin, it will simply vaporize upon heating, reducing or eliminating the sonic cavitation.

In addition to the proper fluid layer thickness, it is also important to insure that the fluid is flowing over the workpiece. In this manner, the heat and debris can be removed during machining.

Turning to the claims, in order to expedite prosecution, applicant has cancelled claims 21 to 36 and 56 to 88 which were withdrawn in response to two previous restriction requirements. Independent claims 1 and 37 remain in the application and were amended to more particularly point out and distinctly define the subject invention.

Turning to the Office Action, various claims were rejected as being either anticipated or rendered obvious, either alone or in combination, by the following references: Roth (Novel Technique for High-quality Microstructuring with Excimer Lasers – Roth 1); Borden (6,066,032); Tam (J. Appl. Phys, April 1992); Zhu (Laser Ablation of Solid Substrates in a Water-Confined Environment); Zapka (Efficient Pulsed Laser Removal of 0.2 Micron Sized

Particles from a Solid Surface); Elliot (5,669,979); Roth (Specific Surface Treatment by Laser Irradiation Under Fluid Films- Roth 2), Uziel (6,827,816) and Drzal (6,565,927). It is respectfully submitted that none of these references, whether taken alone or in combination, teach or render obvious applicant's invention as defined by amended, independent claims 1 and 37.

The two Roth articles (Roth 1 and Roth 2) both disclose laser machining systems where a liquid film is applied to the workpiece during laser irradiation. The Roth articles report improvement in the **quality** of the results from the machining steps. However, the method used by Roth resulted in an undesirable **decrease** in ablations rates. See for example, Roth 1 at page 344 "...the ablation rates of most ceramic and metal material are greatly reduced." See also, page 17 of Roth 2 which states that "...this method reduces ablation rates considerably." It is believed that these reduced ablation rates were the result of using a film layer that was too thick. Indeed, on page 15 of Roth 2, he estimates the film layer "to be several 100 microns thick." As noted above, ablation rates can be maintained and even increased by properly controlling the liquid film thickness to be between 25 and 100 microns. It is submitted that neither of the Roth articles teach this optimum thickness.

The patent to Borden was cited for its teaching of recycling fluids. It is respectfully submitted that the patent to Borden, which relates to wafer cleaning with a carbon dioxide snow spray, fails to overcome the deficiencies of the Roth articles in anticipating or rendering obvious applicant's invention as defined by amended independent claims 1 and 37.

The articles by Tam and Zapka are similar in that they both relate to techniques wherein a pulsed laser is used to clean particulates from a semiconductor wafer. In both of these techniques, the authors use an extremely thin fluid layer, on the order of a micron in thickness (see the Abstract of both articles). In this technique, the laser light is used to superheat the very thin liquid layer, causing "explosive evaporation" resulting in cleaning of the surface **without damaging the underlying substrate**.

The technique used by Tam and Zapka to clean a substrate is quite different from the applicant's ablation technique. As noted above, in applicant's invention, the fluid layer needs to be thick enough so that the vaporization is contained, creating microbubbles that help ablate the underlying substrate. Thus, in applicant's invention, the thickness of the water layer is chosen to improve **removal** of material from the substrate rather than protect the substrate from damage.

Tam and Zapka's selection of an extremely thin layer of fluid is to allow removal of particulates **without damaging the substrate**. Even if the devices used by Tam or Zapka were "capable" of forming a 50 micron thick fluid layer as the Examiner suggests, one skilled in the art would not do so since that would lead to damage of the wafer, a result Tam and Zapka want to avoid. Since there is no suggestion that the devices in Tam and Zapka were operated in a manner to create a thicker liquid film layer, and one skilled in the art would avoid using the devices in such a manner, these references cannot form the basis of a rejection of the amended, independent claims.

The Zhu article relates to laser ablation of materials using a "water confinement regime (WCR)" configuration. In this approach, the workpiece is placed in a glass cuvette and submerged under a static water layer. Zhu reports optimal results when the static water layer has a thickness of 1.1 mm. With this thickness, Zhu achieves an ablation rate of 62 nm/pulse. Zhu also reports experiments with a thinner static water layer, created by water vapor condensation. Experiments with the thin (about 50 micron) layer achieved an ablation rate of only 19 nm/pulse. Zhu suggests that this poor performance is because the plasma layer cannot be tightly confined within the layer (page 1397, top of second column). In fact, applicant believes the poor results achieved by Zhu with a thin water layer was because it was a static layer and not a flowing layer as in applicant's invention.

As can be appreciated, since Zhu uses a static "water confinement regime," his teaching alone cannot anticipate the invention defined in amended independent claims 1 and 37. Further, one skilled in the art reading Zhu would be motivated to use a relatively thick, 1.1mm liquid layer which provided much higher ablation rates that a thin liquid layer. Thus, the teachings of Zhu fail to overcome the deficiencies of the primary references in rendering obvious the amended, independent claims.

The patent to Uziel was cited for its teaching of "steam spraying." Uziel relates to a particle removal system. Uziel suggests depositing a vapor film on the substrate which condenses into a liquid film. Uziel fails to discuss the thickness of his film that is created via this approach. However, it is likely that the layer is quite thin since he states that the liquid film "explosively evaporates" in response to the laser irradiation, a description which is consistent with the very thin films described by Tam and Zapka discussed above (see, column 7, line 53 of Uziel).

The patent to Elliot was cited for its teaching of computer controls as well as filtering and recirculating fluids. Elliot is directed to a system for removing photoresist from the surface of a wafer. In one embodiment, a fluid having a reactant such as hydrogen peroxide is passed over the substrate. Elliot suggests a fluid depth in the range of 0.5mm to 20mm, much thicker than the thickness range set forth in claims 1 and 37 (see, column 18, line 67+).

The patent to Drzal was cited for its teaching of using steam during surface treatments. In the Drzal system, radiation is provided by a UV generating flashlamp rather than a laser. In one embodiment, water is sprayed onto the surface of the workpiece to create "very small droplets, less than1 micron in diameter." (column 9, line 24+) Alternatively, Drzal suggests using a very thin continuous layer of water.

It is respectfully submitted that the patents to Uziel, Elliot and Drzal, whether taken alone or in combination with the other art of record, fail to anticipate or render obvious applicant's invention as defined by the amended independent claims which require establishing a thin, flowing layer of fluid across the workpiece and wherein the thickness of the layer is in the range of 25 to 100 microns to facilitate machining of the workpiece by the laser beam.

In view of the above, it is respectfully submitted that amended independent claims 1 and 37 define patentable subject matter and allowance thereof, along with the claims depending therefrom is respectfully solicited.

As a final housekeeping matter, it is noted that the Examiner initialed all of the US Patents and articles listed on page 2 of the 1449 form filed June 1, 2004 and also initialed all of the articles listed on page 1 of that same 1449 form. However, the Examiner did not initial the US Patents listed on page 1 of this 1449 form. Copies of these US Patents were submitted to the

Examiner and it is believed that that the omission of the Examiner's initials is merely an oversight. Applicant would appreciate receiving a corrected 1449 form as part of the next communication with the Examiner.

Respectfully submitted,

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